

## The “Wave Form” or the squiggly line on many finger pulse oximeters

By John R. Goodman BS RRT

Sometimes technological advances seem to happen almost overnight, and sometimes it seems to take forever before someone has the “I could have had a V<sub>8</sub> moment.” For patients on oxygen 24 hours per day, a digital or finger pulse oximeter is an essential piece of kit. For any new oxygen patient the ease, accuracy, and mostly the price of today’s finger pulse oximeters make it a simple process of walking into your nearest Walgreens or similar store and buying what is on the shelf. For those patients who like to cruise the internet, there are literally thousands of models available at a keystroke.

As I sit here writing this article (September 2015) the lowest price I could find for a basic oximeter was just \$15.00 with free shipping and a one year warranty. That means for about \$1.25 a month you have one of the most sophisticated monitoring devices available. As always a little history lesson will prove helpful here.

If it weren’t for ever higher flying aircraft, the oximeter might have taken many more years to be invented. Credit for the very first oximeter is normally given to Karl Matthes. Matthes was a German scientist who was studying the effects of low blood oxygen levels in pilots at very high altitudes. His oximeter was a bit crude, and difficult to apply to the pilots, but it did work and believe it or not the same principle is used in all oximeters to this very day. A few years later a US scientist named Glenn Millikan invented a much easier way to measure the pilots oxygen saturation using an ear probe to make his measurements. Milikan also actually coined the term “oximeter.”

It wasn’t until 1964 that Hewlett Packard introduced the first commercialized ear oximeter into a perfect storm of a newly developed concept that today we call the ICU. At this point oximeters were almost massive by today’s standards, required a great deal of calibration and upkeep, and finally were very, very expensive. In fact, the first HP oximeter required its own cart to move around, and cost \$10,000.00 or \$75,327.00 in 2015 dollars.



My oh my have oximeters come down both in size and price since the original HP back in 1964!

Since those days the oximeter slowly improved in accuracy, ease of use, the addition of other clinical components, and of course the prices have come way, way down. As physicians, scientists, and engineers began to refine the whole field of oximetry, most of the technical advances were in the area of making the oximeter more accurate, easier to read, and of course making the footprint much smaller. Finally, in 1995 the Nonin company introduced the first true digital pulse oximeter. This was truly the “I could have had a V<sub>8</sub>” moment. The Nonin digital pulse oximeter allowed oxygen patients in the home *exactly* what was needed for a burgeoning home oxygen market. In the following 20 years, many manufacturers developed their own competitive line of finger pulse oximeters. A huge worldwide market stimulated research and development and along with lower prices other useful displays began to be built into succeeding generations of oximeters. So it may seem that small, affordable oximeters were always available, but the reality is they have only been around for the past 20 years or so.



The Nonin Digital Pulse Oximeter started the paradigm shift in the routine monitoring of oxygen saturations in the home.

One of these developments had to do with the cardiac side of the oximetric equation. We all naturally focus on the two main readouts of oxygen saturation and heart rate or pulse. However, depending on which actual model of oximeter you buy, it might also display information regarding the effect of your blood as it moves through your circulation with each beat of your heart. This has a long medical term to describe it and is called a Photoplethysmogram. (PPG) In everyday use we simply call it the “Waveform.”

The wave form is an overall reflection of the volume of blood that is circulating with each beat of your heart. This can easily be detected with your finger pulse oximeter and the fluctuation in blood flow is normally shown as a (squiggly) line along with the readings for saturation and heart rate. Given a choice of an oximeter with or without the wave form any good respiratory therapist would pick the oximeter with the wave form without hesitation.



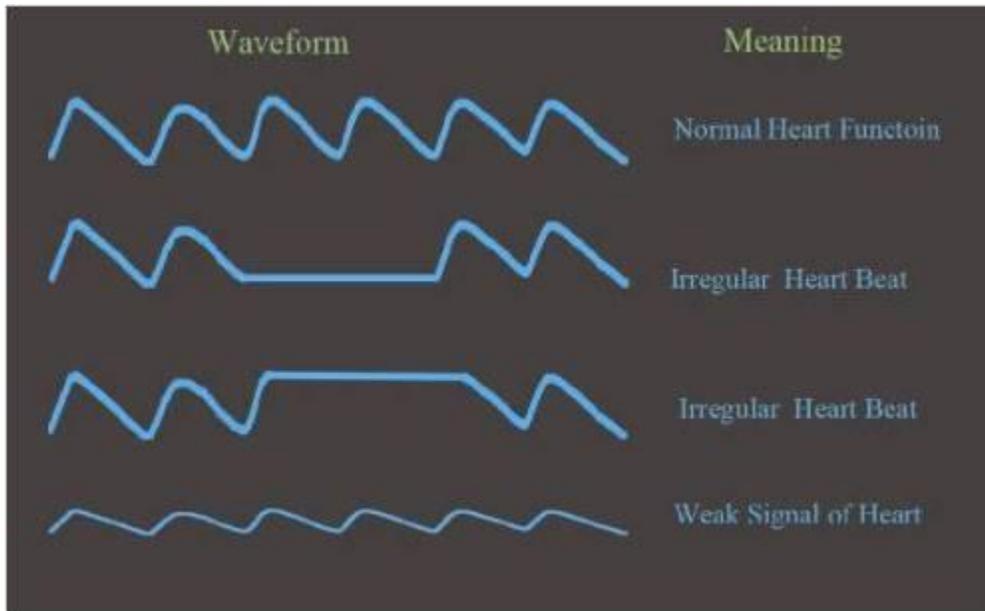
Oximeter with Wave Form



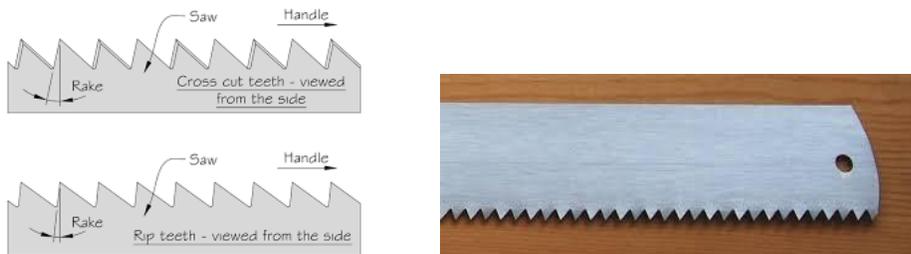
Oximeter without Wave Form

The waveform gives moment by moment information allowing detection of an irregular heart rhythm. This is NOT an EKG tracing. It has nothing to do with the electrical system of the heart. In this way it might be possible to pick up an early warning sign that can be brought to the attention of the patient’s physician. The

wave form also gives information regarding the strength of the signal itself. It is displayed as amplitude. In other words the actual size of the wave form may indicate a problem that might cause inaccurate readings of saturation. This may be caused by a decrease in blood flow through the finger (called low perfusion), improper position of the oximeter on the finger; it can even be due to dirty sensors or LED lights.



For most patients on home oxygen, it is the shape of the wave form that is easiest to see virtually every time you are checking your oxygen saturation. The shape of a normal wave form is most commonly described as “saw tooth.” That is, the way a good rip saw looks if you just look at the teeth.



The closer your own wave form looks like these images, the more likely you are to be getting reproducible and accurate recordings of your saturation and heart rate.

If you see a saw tooth pattern, whose amplitude takes up at least half of the display area, you are probably getting the most accurate readouts of saturation and heart rate. In fact a number of oximeters will simply not display any numbers until it “recognizes” a normal wave form configuration. Others might show dashes or

other indications that some condition is not being met according to that particular oximeters measuring algorithm. All in all, the wave form is an important feature of slightly more advanced and expensive oximeters. Considering that oxygen is by far the most important drug you are taking and you can have this technology for literally pennies per day, it is one of the best investments you are ever likely to make.